By Woo Yin San and Romeo Roger

Real-Time Hydraulic Modelling Systems

Leveraging Data and Information to Lead Digital Transformation of Water Distribution Networks

This article aims to discuss the advantages of technology evolution in water utilities – real-time hydraulic modelling system.

Malaysia is blessed with an average of 2,500 to 3,000mm of rainwater yearly, which is two to three times more than the annual mean global precipitation. On average in Asia and the Pacific, it is estimated that the annual available renewable water resources per capita is 4,817m³, while Malaysia is at 18,700 m³/capita (Zakaria, 2015 and Academy of Sciences Malaysia, 2016). Yet, why do we encounter water disruption and low pressure despite the 'water abundance'? Are we implementing the suitable decision support tools to ensure an efficient and effective management in water utilities?

What is a Model?

One may find the word 'model' uncommon, but we see models everywhere and every day. For instance, a miniature car model at home or a water purification demonstration model. A model is a simplification or representation of the real world, which can be categorised into physical, conceptual, and mathematical types. A physical model is a replica of a real object or system, this model often uses observation or experimental outputs as model validation, e.g. open channel model while a conceptual model employs theoretical hypotheses to interpret or for the reasoning of a (complex) system, e.g. ecology or climate model. A mathematical model, on the other hand, describes mathematical relationships to compute or analyse a system, e.g. hydraulic model (HM) is a physics-based mathematical model.

Modelling is a process of understanding system behaviour by using tools (models) that represent the paradigm and dynamics of a real system. A modeller or model user may understand the system of interest by reducing the complexity and identify underlying potential challenges via modelling. Reliable modelling outcomes are capable of reflecting the dynamics of a real system, thus, providing fruitful insights to users. In the water supply and distribution field, hydraulic modelling is a common but essential practice. A hydraulic model computes the relationships between pipe (and node) characteristics and critical hydraulic parameters.

Why Hydraulic Modelling?

Today, a hydraulic modelling system (HMS) is either a standalone system or an integrated system with Geographic Information System (GIS). A well-built hydraulic model acts as an information hub containing spatial and temporal data of a water distribution network (WDN). For instance, the location of pipes/reservoirs/valves/pumps, dates of pipes installation, controls of valves and pumps and consumer demand profiles can be displayed at a glance. A WDN often consists of extensive pipe connectivity and control philosophies. Hence, it is impractical to require all employees (especially the newcomers) to be familiar with and master the network details within a short timeframe. Thus, an HM becomes handy in providing an overview of network connection and operation information that might only be available to senior operators previously. Most importantly, an HM is capable of performing calculations efficiently compared with laborious manual calculations, enabling critical hydraulic parameters such as flow, pressure and head loss of each pipe and node to be available in seconds or minutes. Also, hydraulic modelling is used to run simulations with different scenarios to examine how a real-world WDN reacts.

Water operators are obliged to evaluate and develop a safe and sustainable water distribution system with the challenges of growing water demands (especially due to urban population growth) and ageing infrastructures. Thus, an HMS is undoubtedly one of the crucial tools in supporting water operators in strategic planning; not limited to developing WDN master plans, assessing development expansion and evaluating maintenance plans. Water operators may utilise an HMS to investigate or assess the current WDN conditions under different (what-if) scenarios to simulate possible or desired outcomes before implementing action plans at the actual WDN. The most vulnerable areas or the most impactful consequences to the network if certain critical equipment breaks down will be identifiable by utilising the digital WDN. Thus, preventive rehabilitation and emergency response plans will be readily available before any

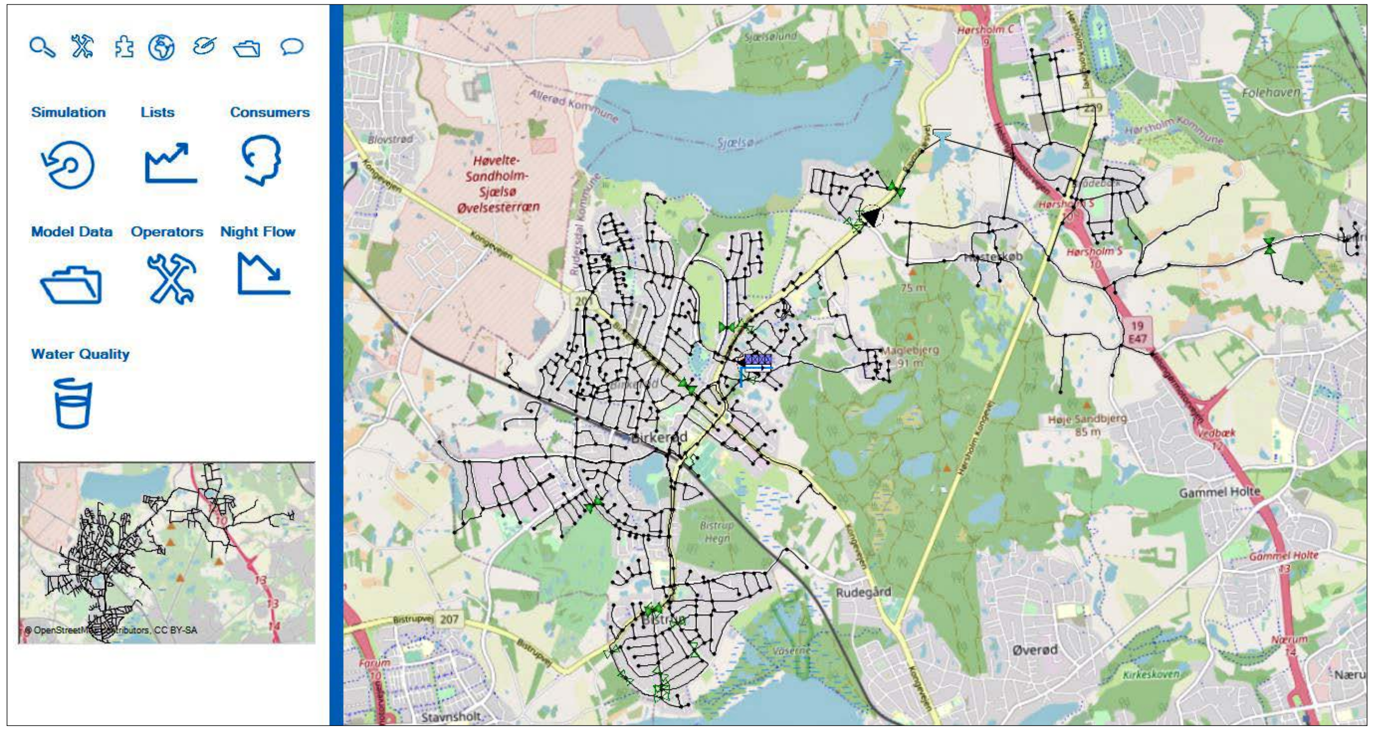


FIGURE 1 **Example of a Hydraulic Modelling Software Dashboard**

equipment failure. Moreover, to ensure safe drinking water is distributed to consumers, water qualities such as water age and disinfectant or contaminant concentration are available to water operators to compute the fate of chemicals and identify the affected areas. The HMS functionalities in the industry include analyses of fire-flow, minimum night flow, water balance, pump optimisation, energy saving, and others.

Typically, the HM simulation will only run in batch mode or when needed based on historical data. For instance, even if the model is simulated with today's data, the simulation results will become solely as historical references the next day, unquestionably. Hence, an always up-to-date HMS becomes a 'game-changer' along with the evolution of technology.

What's next?

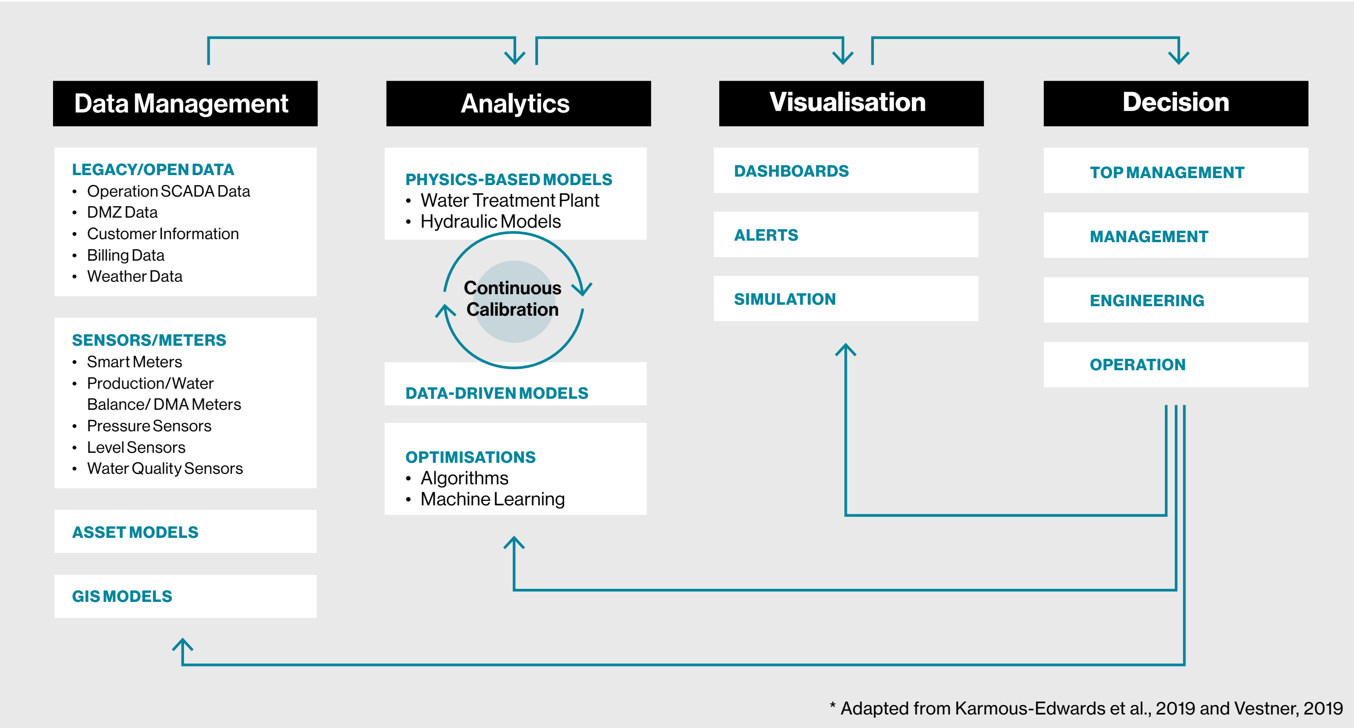
It is worthwhile to explore the potentials of HMS and to move forward in Malaysia's water sector, especially with the emergence of digital transformation. A real-time HMS is made available with advancing technology to integrate with Supervisory Control and Data Acquisition (SCADA) and other systems. Conventionally, hydraulic measurements were collected and stored on the SCADA database, yet seldom or never utilised, resulting in a limited operational overview.

The objectives of a WDN HMS are no longer limited to strategic planning, but transforming to daily operational data-driven monitoring and analyses. The integrated system enables the HMS to receive real-time hydraulic data and to simulate the WDN hydraulics (and water quality) in real-time. Truly, it is a vital real-time decision support tool in operation that allows water operators to evaluate the current operational conditions by a few clicks on the dashboards. Operators are able to compare actual measurements with simulated results to react on abnormal events, engineers are able to execute the best pump operation strategies to optimise energy and cost saving while managers are able to review the WDN performance and implement the most efficient asset management system.

Another major advantage of real-time HMS is breaking down communication silos between departments and data utilisation. The traditional means of updating an offline model require data gathering from different departments, recalibrating the model and rerunning simulations. The whole process is time consuming and may take up to weeks due to the manual outreach to various data sources. Meanwhile, a real-time HMS combines automated update and continuous information from the operation, billing, non-revenue water, and even weather departments without much manual intervention. Water operators may fully utilise the gathered information including to predict reservoir level and usage demands, create contingency plans and act accordingly - remodeling the management from a reactive to a proactive approach as well as warrants a design-efficient and cost-effective WDN.

The reliability of a model is one of the greatest concerns. The fundamental of modelling - garbage in, garbage out (GIGO) where the model results are reflected by its input quality, e.g. elevation, network connectivity, measurement locations, and valid measurements - means that data measured, transfer and retrieval must be systematic and error-free to prevent faulty interpretation and

FIGURE 2 **Roles of a Real-Time HMS and Other Resources in Digital Twin***



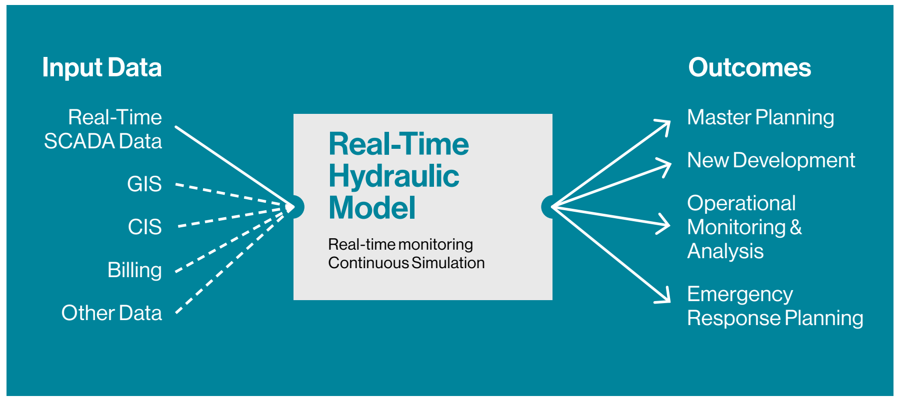


FIGURE 3 **Example of Inputs and Possible Outcomes of a Real-Time HM**

decision. Besides, model calibration is another determinant of the reliability and usefulness of a real-time HMS. For instance, a real-time model is unlikely to perform if it is calibrated in batch mode with outdated asset information or historical operational controls.

A real-time HMS serves as a basis for improving efficient and effective decision-making, increasing interdepartmental collaboration and operational transparency. This transformation takes time, effort and monetary investment to succeed as well as the overcoming of unseen cultural barriers. The continual connection of breaking siloed systems like integrating real-time HMS, SCADA, GIS, billing system, and algorithms to evolve into a Digital Twin ultimately, should diversify the benefits to our water sector both technically and culturally.

Reference list of abbreviations:

GIS	Geographic Information System
HM	Hydraulic model
HMS	Hydraulic modelling system
SCADA	Supervisory Control and Data Acquisition
WDN	Water distribution network

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